REMARKS/ARGUMENTS

In response to the Office Action mailed March 23, 2006, Applicants request reconsideration in view of the following remarks. No claims are added, cancelled, or amended so that claims 1-20 remain pending.

Of the claims pending, claims 1, 5, and 9 are independent claims. If those claims are patentable, then so are the remaining claims 2-4, 6-8, and 10-20. Accordingly, the following comments focus principally on those three independent claims.

Claim 1 is directed to a method of manufacturing a semiconductor device in which, after forming a first insulating film on a substrate, a second insulating film is formed in a complex process that includes a plurality of repeated and continuous cycles. Each cycle includes supplying film-forming materials to the first insulating film so those materials can be adsorbed. Then, in the second step of the cycle, the film-forming materials that have not been adsorbed are purged. In the third step of the cycle, oxidants are supplied in order to oxidize the adsorbed film-forming materials. Finally, the oxidants that have not contributed to the oxidation of the film-forming materials are purged in a second purging step of each cycle.

An important feature of the method defined by claim 1 is that, in an initial number of the steps of purging the oxidants, longer purging times are used than in the purging steps of later cycles.

Important advantages are achieved according to this method. The patent application describes similar processes in which all of the oxidant purging cycles are of identical length and are of two different lengths, namely 7.5 seconds and 90 seconds. Measured data reported in the patent application with regard to Figures 3A and 3B illustrates, as expected, cleaner interfaces are achieved in the multiple cycles when the longer purging time, 90 seconds versus 7.5 seconds, is employed. However, since that longer purging time is 12 times longer, using the longer purging time unduly extends the process of forming the second insulating film. That second insulating film is slowly built up by alternately adsorbing the film-forming materials and oxidizing those materials.

The invention, particularly as described by claims 1 and 9, provides a substantial improvement, providing clean interfaces between the films that are built up as the second

insulating layer is deposited while shortening the time of film deposition. According to the invention, the purging of the oxidants takes place for relatively long times in initial cycles and during shorter times, i.e., second purging times, in the remaining cycles. The examples described in the patent application and in dependent claims 4, 8, 12, 16, and 20 provide for an initial number of relatively long purging times for the first 10 or 20 cycles and then shorter purging times for the remainder of the cycles in depositing the second insulating film. Using specific examples of the patent application, the initial times may be 90 seconds in duration and the later shorter purging times may be 7.5 second in duration.

Using the two different purging times substantially reduces the total time required to deposit the second insulating film. Nevertheless, a substantial improvement in performance is achieved in the invention because of the cleanliness of the interfaces between the films. Evidence of this improvement is shown by the measured data reported in Figure 4 of the patent application. That graph shows measured leakage current for voltages applied to insulating films made according to a conventional method in which all purging times are relatively short, plotted as solid lines in Figure 4. Leakage current for similar devices in which the purging times are all relatively long, for example, 90 seconds, are shown in that Figure 4 by the lines that include alternately long and short lines. Finally, the leakage current characteristics of devices made according to the invention in which the purging times for only the initial ten cycles are relatively long and are followed by shorter purging times for later cycles are shown by the dashed lines. Those broken lines show that the leakage current for an applied voltage is significantly reduced over the conventional method with the relatively short purging times and represents only a small increased leakage current as compared with the undesirably long deposition process when all of the pursing times are some 12 times longer than the shorter purging times.

Claim 5 is directed to a similar method in which the purging times are different in initial cycles and in later cycles but for purging as to the film-forming materials rather than the oxidants. Similar advantages of shortened deposition times without a sacrifice in leakage current characteristics are achieved according to this method.

Claims 1-20 were again rejected as unpatentable over Ahn et al. (U.S. Patent Publication 2004/0175882, hereinafter Ahn) in view of Chang et al. (U.S. Patent 6,884,719, hereinafter Chang). This rejection is respectfully traversed.

The Examiner explained the application of Ahn at pages 2 and 3 of the Office Action. Applicants generally agree with that description of Ahn. Ahn describes atomic layer deposition (ALD) of a film that is ultimately an insulating film by alternately depositing a film-forming material and oxidizing that material with an oxidant, with intervening purging steps, as illustrated in flow diagram of Figure 4 of Ahn. What is not described by Ahn, as acknowledged in the Office Action, is the use of purging times of different lengths in different cycles in the Ahn deposition process as represented by repetition of steps 430-445 of Figure 4 of Ahn.

According to the Office Action, it would have been obvious, presumably in view of Ahn considered by itself, to change the purging times as in the invention, because those changes produce no unexpected "function". Of course, what should be considered is not whether any different on unexpected "function" is achieved because of the difference between the invention and Ahn, but whether some important, useful, and unexpected *result* is achieved.

As already described above, two important useful improvements are achieved according to the invention because of the different purging times used in the initial cycles and in subsequent cycles. A substantial improvement in the cleanliness of the interfaces between the sequentially deposited films is achieved as demonstrated by the measured data of Figure 4 showing that a reduction in leakage current of the films so produced is achieved. Further, that result is achieved without sacrificing deposition time. As previously explained, if all of the purging times are of the same length, and the purging times were sufficiently long to achieve the desired interfacial cleanliness and leakage current characteristic, then the total deposition time would be unduly long. The invention achieves the desired leakage current characteristic improvement while, at the same time, avoiding unduly long deposition times. These improvements achieved according to the invention demonstrate that the invention is not obvious in view of Ahn considered by itself because, contrary to the assertion of the Office Action, different, improved, and unexpected results are achieved in the invention. The results are unexpected because the

known improvement achieved when all of the purging times of the same, relatively long length are effectively achieved without that unduly extended deposition time.

In acknowledging that the invention as defined by the three pending independent claims cannot be obvious in view of Ahn considered alone, reliance was placed upon Chang. Chang was cited for two different propositions. First, Chang was cited as describing the initial deposition of an insulating layer, the first step of each of the independent claims, a step that is clearly absent from Ahn. Accepting that Chang supports that proposition, Chang would still not suggest the part of the claimed invention that is missing from Ahn.

In attempting to fill in the remaining differences between the claimed invention and Ahn, further reliance was placed upon Chang because it discloses, in an ALD process, a higher oxidant flow rate in a first reaction cycle for a longer period of time than in subsequent cycles. Column 10, lines 45-53 of Chang were cited with respect to this proposition. That passage refers to the graph shown in Figure 3 of Chang.

Figure 3 of Chang is clearly a time chart illustrating three sequential cycles of adsorbing a precursor material on a surface followed by supplying of an oxidant in an oxidation/annealing process to produce a film of an insulating material. Such films are repeatedly deposited to build up the thickness of the layer. Although not expressly stated in Chang, time is plotted on the abscissa of Figure 3 of Chang and the three sections of that graph show the cycle underway, the relative flow rates and the relative temperatures in each of three cycles. With that understanding, it is apparent that the empty spaces within and between cycles, for example between what is designated as precursor and oxidation/annealing and between oxidation/annealing and precursor, represent times in which, presumably, some kind of purging process takes place. Chang only uses the word purge in any form once. For that reason alone, it is questionable whether Chang is even pertinent to the obviousness question that is being focused upon in this examination.

Presuming that undisclosed purging does exist in the process described by Chang, solely for the sake of argument in response to the hypothesized rejection, that is apparent from Figure 3 of Chang that purging times never change within a cycle or between cycles. Accordingly, contrary to the assertion of the Office Action, Chang could never suggest a

modification of Ahn in which the duration of the purging times is different in different cycles.

According to the Office Action at page 3, because Chang discloses, as clearly shown in Chang's Figure 3, that the oxidant flow rate and the temperature of the oxidation/annealing process are both higher in cycle 1 than in cycles 2 and 3, it was asserted that "it would have been obvious that the purging process time will be higher in the first reaction cycle than in later cycles to remove greater excess oxidants in the first reaction cycle." That assertion is plainly erroneous and finds no support whatsoever in Chang. In fact, what is described in Chang, to the extent there is any implicit description concerning any purging times, is what appears in Figure 3 of Chang. As already stated, that time graph shows uniform purging times from cycle-to-cycle and cannot provide any suggestion for modifying Ahn to produce the claimed method.

The only possible sources of the assertion that Chang could teach varying purging times are speculation and knowledge of the claimed invention. One could speculate further with respect to Chang. For example, since the oxidation/annealing temperature according to Figure 3 is higher than in cycles 2 and 3, some longer cooling time might be required before beginning cycle 2 than in the interval between cycles 2 and 3. However, there is no teaching nor suggestion for such a time delay in Chang. The kind of speculation that produces this hypothesis is no different from nor any more supportable than the speculation that is the basis for the rejection for obviousness. Similar process variables could be the subject of still other examples of such speculation, but the single example is sufficient to demonstrate that *prima facie* obviousness cannot properly be based upon a hypothetical teaching of Chang that is nowhere found in Chang.

The other source of information that might have been relied upon for the rejection, the present patent application itself, cannot be the basis of a proper rejection for obviousness. Whether the ground for such a rejection is called "hindsight" or something else, an inventor's disclosure cannot be used against itself to establish obviousness.

The alleged motivation for the asserted combination of Ahn and Chang appearing in lines 4 and 5 at page 4 of the Office Action simply does not find any support in the prior art. According to Chang, his process, which does not include varying of purging times, is sufficient to avoid the presence of dangling bonds. Ahn is not needed to produce

that result. The assertion that a "smooth channel region top surface" would be achieved by modifying Ahn with Chang, resulting in higher electron mobility, is speculation without support in either of Ahn or Chang. Only experimental evidence could produce that kind of information. No experimental evidence was supplied to support the assertion. Therefore, the alleged motivation for the modification of Ahn with Chang is the product of speculation, not objective evidence in the prior art, a fundamental requirement to establish obviousness. *In re Fine*, 5USPQ2d 1596 (Fed. Cir. 1988).

Prima facie obviousness simply has not been established here because all of the elements of the claimed invention are not present in the two publications relied on, namely longer purging times in initial versus later cycles of film deposition, so that no combination of Ahn and Chang could establish *prima facie* obviousness of any claim. Further, motivation for modifying Ahn with Chang has not been established so that the second of the two essential elements of establishing obviousness is also missing. Therefore, reconsideration and withdrawal of the rejection as well as allowance of all of claims 1-20 are earnestly solicited.

Respectfully submitted,

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Date: May 9, 2006
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